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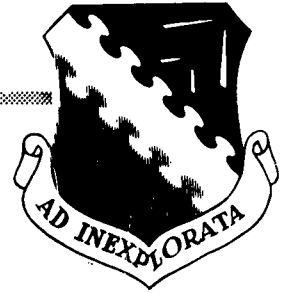


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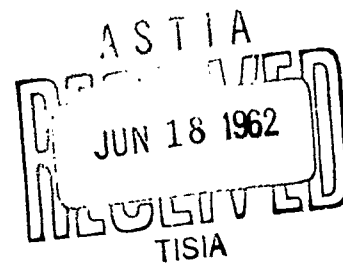
C-130 DUAL RAIL AERIAL DELIVERY SYSTEM FOR HEAVY EQUIPMENT DROP

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**AIR FORCE FLIGHT TEST CENTER
EDWARDS AIR FORCE BASE, CALIFORNIA
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE**

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ABSTRACT

This report presents the results of a program to evaluate a C-130 dual rail modification for a fixed pin 108-inch platform usage for single unit drops in the range of 27,500 to 35,000 pounds, an evaluation of the fixed pin 108-inch "Comex" combat expendable platform, and evaluation of flying qualities (stability and control) of the C-130B during heavy drop aerial delivery. Force-time histories during parachute deployment and opening in the individual load suspension slings and parachute risers were obtained.

Tests determined that the Aerial Unloading Kit, Model AF/A32H-1, although generally functionally suitable for use with the 108-inch "Comex" platform for drops in the range of 27,500 to 35,000 pounds, should not be accepted for operational use until the modifications as recommended in this report are accomplished. The 24-foot "Comex" platform is suitable for air drops of unit loads of from 27,500 to 35,000 pounds. Inadequate instrumentation prevented the determination of any flight safety conditions involving the exceeding of design limitations of the aircraft when air dropping unit loads with weights ranging from 27,500 to 35,000 pounds. Test results also indicate that the AR/AAV vehicle can be dropped from a C-130B aircraft without encountering any aircraft load-clearance problems.

*This report
has been
reviewed
and
approved*

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1 INTRODUCTION

AUTHORITY

The authority for the testing reported herein is Air Research and Development Command message RDRA 2-11-2, dated 2 November 1960, which granted approval to proceed with a test program as outlined in Wright Air Development Division message 28-10-254, dated 29 October 1960, Subject: Emergency Test Directive for C-130 Aerial Delivery System and Cargo Containers. The test program, titled: "C-130 Dual Rail Aerial Delivery System for Heavy Equipment Drop and Cargo Containers," Project No. 8044, USAF Priority 2, ARDC Precedence 48A, consists of two parts: Part I - Functional Evaluation of Rail Modification for Fixed Pin 108-inch Platform Usage for Drops from 27,500 to 35,000 Pounds; Part II - Engineering Tests of Air Force Re-Supply Platform for Drops up to 8000 Pounds. This report constitutes closing action of Part I of the WADD test program, identified locally as FTL-223.

PURPOSE

The original test objectives were:

1. Functional evaluation of a C-130 aircraft dual rail modification for a fixed pin 108-inch platform usage for single unit

drops in the range of 27,500 to 35,000 pounds.

2. Functional evaluation of the fixed pin 108-inch "Comex" combat expendable platform.

3. Evaluation of flying qualities (stability and control) of the C-130B aircraft during heavy drop aerial delivery.

In addition to the original test objectives, the following were investigated:

1. The Army Quartermaster Research and Engineering Command requested that force-time histories during parachute deployment and opening be measured in the individual load suspension slings and recovery parachute risers.

2. WADD requested that a mock-up be constructed on a test load to simulate the critical external dimensions and cg location of an Army vehicle called the AR/AAV and that the test load be air dropped. This was done to determine whether any aircraft load-clearance problems could be encountered if this vehicle were air dropped from the C-130B.

2 TEST PROGRAM

TEST ITEMS

Aerial Unloading Kit, Model AF7A32H-1:

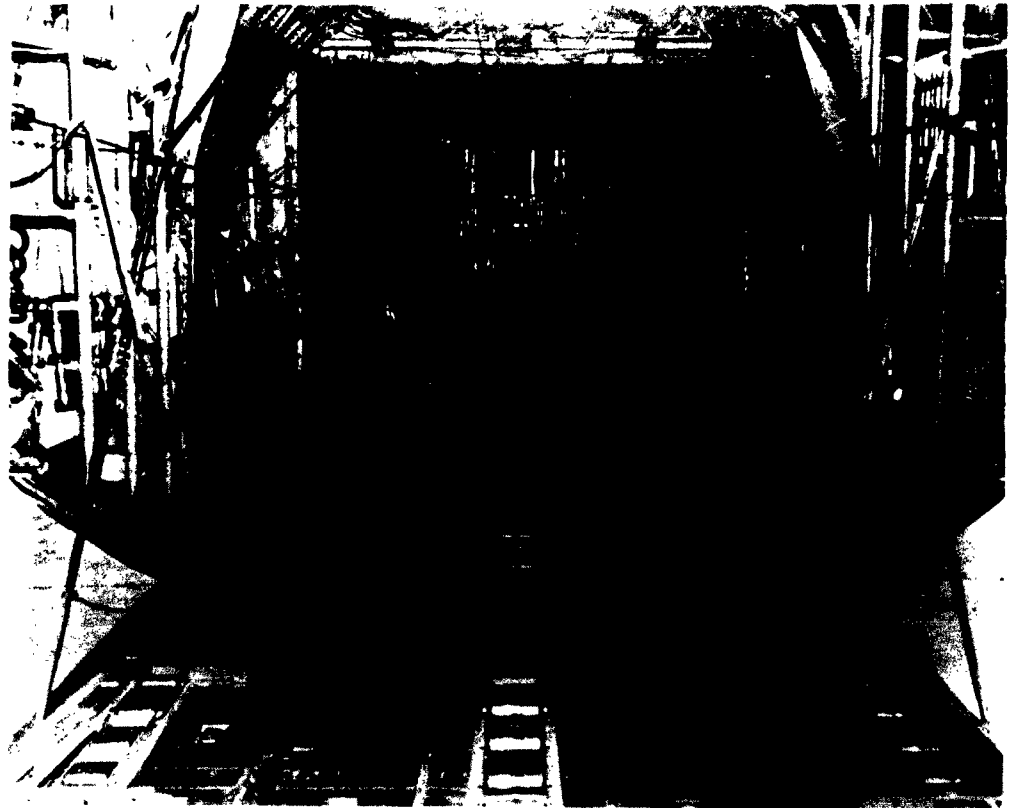
This item was developed by Brooks and Perkins Incorporated, under contract No. AF 33(600)-41832. The item USAF Drawing No. 13376-100 is an improved version of a similar item developed by the same company under a previous contract and which is not standard equipment for the C-130 aircraft. This improved aerial unloading kit provides four main improvements:

1. Automatic "locking in place" of platform.
2. Fixed pin platform usage.
3. A maximum single unit-load capability of 35,000 pounds.

4. Increased platform width - from 104 inches to 108 inches.

The item consists of 10 conveyor frame assemblies and a 5-section auxiliary conveyor. A 5-section conveyor frame assembly is mounted on the aircraft floor at each side of the cargo compartment and continuing on the ramp. The auxiliary conveyor is also mounted longitudinally on the aircraft floor and ramp and is centered between the conveyor frame assemblies (Figure 1). Vertical restraint and lateral guidance of the aerial delivery platforms are provided by the frame assembly rails. Rollers, in the frame assemblies and in the auxiliary conveyor, provide vertical support and facilitate the loading and extraction of the loaded platforms.

FIGURE 1



Latch mechanisms on the rails restrain the platforms from fore and aft movement during flight, and can release the platform automatically at the time of air drop. Platform release is accomplished by the application of extraction force to a cable which is attached to the extraction parachute line and to the extraction parachute cable release mechanism which in turn activates the rail latch mechanisms which disengage the latch hooks from the platform pins. An emergency release system is also provided with the release handle located at the forward-most point of the left rail.

"Comex" Platform:

The "Comex" combat expendable platform, USAF Drawing No. 13376-500, was also developed by Brooks and Perkins Incorporated, under contract number AF 33(600)-41832. This item consists of panel sections, side rails and accessory fittings. The panels are 108 inches wide and come in 4-foot sections to allow flexibility in selection of platform length. The panels are of sandwich construction with thin aluminum skins bonded to a foamed-plastic core and a frame made up of special aluminum channels. The special extruded aluminum channels used in the panel frame provide an interlock with the platform side rails. The side rails are made of extruded aluminum and are pre-cut to 8-, 12-, 16-, 20-, and 24-foot lengths to provide flexibility in selection of platform length. Field assembly is readily accomplished by installing drive rivets in pre-drilled holes in the panels and rails. The accessory fittings consist of the platform restraint pin fittings which engage in the latches of the aircraft side rails to provide fore and aft restraint of loaded platforms, and the cargo tie-down rings. The accessory fittings are bolted to the platform side rails. The only tools required to assemble a platform are a hammer for setting the drive rivets and a wrench for attaching the accessory fittings to the platform.

TEST EQUIPMENT

C-130B Aircraft (Modified):

A new production model C-130B aircraft (Serial No. 59-1536) with modified ramp support arm brackets (Lockheed Aircraft Corporation Drawing No. 3400776) was provided by WADD for these tests. This modification provided the aircraft with a 35,000-pound unit-load air drop capability.

Weight-Test Platform:

A weight-test platform (Drawing No. 58H1039) was used as the test load. The test platforms were ballasted with iron plates to obtain the desired weight.

Paper Honeycomb:

Layers of paper honeycomb (Stock No. 1670-753-3928) were used between the weight-test platforms and the "Comex" platforms to minimize platform damage at ground impact and to attain the desired cg height for the load.

Parachute:

Standard stock listed parachutes were used throughout the tests for the extraction and recovery of the loads. Clusters of 22-foot and 28-foot ring-slot parachutes were used for the extraction, and clusters of G-11A 100-foot nominal diameter (D_0) cargo parachutes were used to recover the loads.

AR/AAV Mock-Up:

A wooden mock-up was constructed of 1/4-inch plywood and secured to the test load to simulate the critical external dimensions of the Army's AR/AAV vehicle (Figure 2). The critical dimensions are: width - 110 inches; length - 240 inches; height - 86 inches.

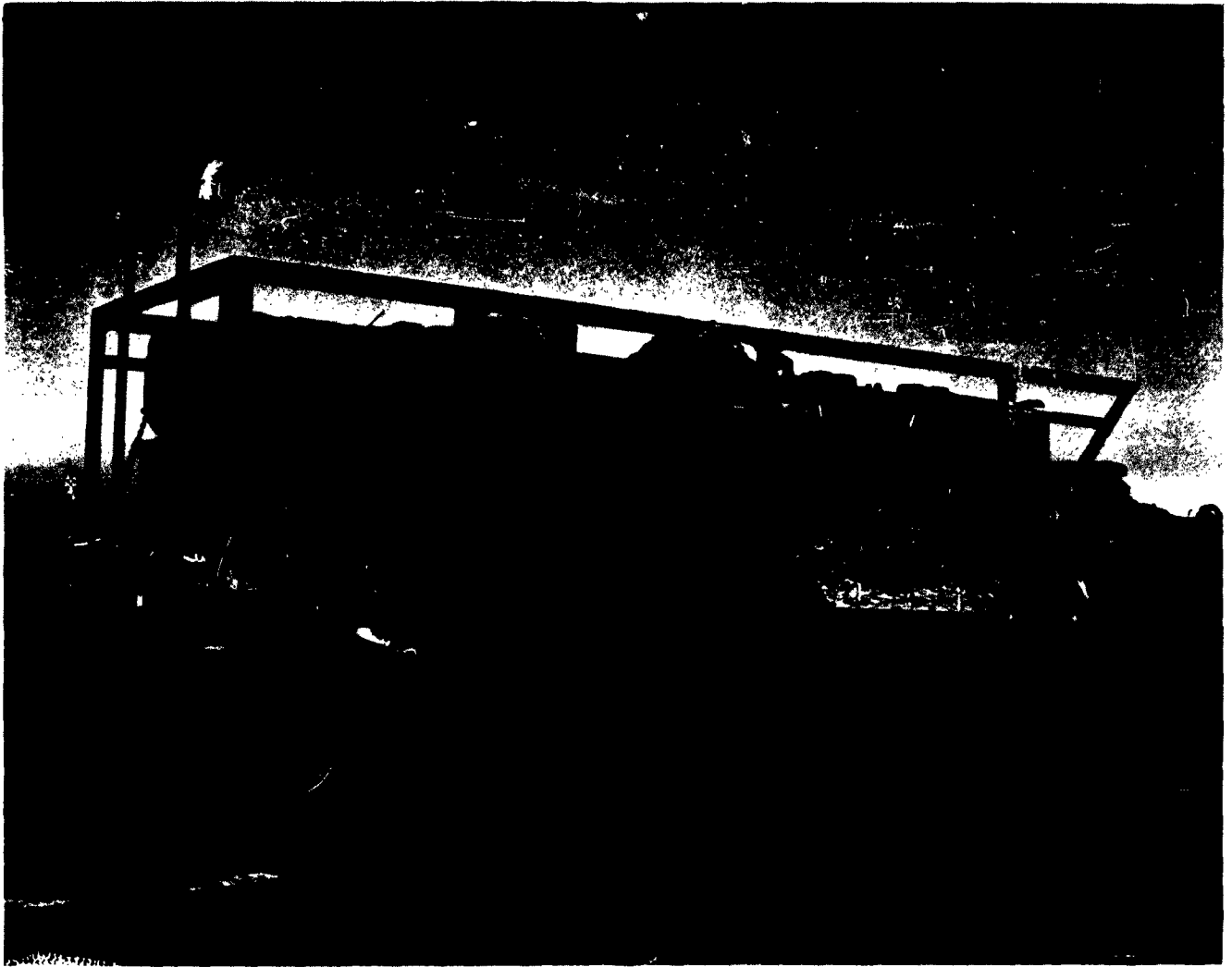


FIGURE 2

INSTRUMENTATION

On-Board Direct Recording System:

Five kinds of measurements were made by this system which was mounted within the aircraft cargo compartment. They were:

1. Ramp Support Arm Forces - Strain gages were bonded to the right and left ramp support arms to measure the tensile forces on the arms during the extraction of the loads.

2. Pitch - A pitch gyro was mounted on the floor of the cargo compartment forward and to the right side of the load at approximately fuselage station 287 to measure pitch change of the C-130B.

3. Rate of Pitch - A rate of pitch gyro was mounted at approximately the same location as the pitch gyro to measure rate of pitch change of the C-130B.

4. Accelerations -

a. A 10-g accelerometer was located midway between the pilot's rudder pedals to measure the acceleration of the nose section of the C-130B in the vertical plane.

b. A 10-g accelerometer was located on the fuselage centerline above the ramp door hinge point to measure the acceleration of the tail section of the C-130B in the vertical plane.

c. Three accelerometers were located on the floor of the cargo compartment slightly to the right of the aircraft centerline at fuselage station 530 to measure acceleration in three axes. A 3-g accelerometer was used in the vertical axis and a 2-g accelerometer was used in each of the other axes (lateral and longitudinal).

5. Rate of Extraction of the Load - A magnetic reel was used to measure the rate of extraction of load; it was mounted on the floor of the cargo compartment just forward of the load.

Telemetry:

Three telemetric packages were used in the instrumentation of this project. One package was installed in the C-130 aircraft just aft of the right side parador and designated the On-Board TM Pack. One package was installed in the platform load suspension coupler and designated the Clevis Pack. The third package was installed on the load and designated the Platform Pack. The measurements made by each telemetric package were as follows:

The On-Board TM Pack was used to record the rate of extraction of the load and to record the tensile forces on the ramp support arms during extraction of the load. All measurements made by the On-Board Telemetric Package were

duplicated in the On-Board Direct Recording System. This provided an alternate source of information in the event of failure of one source.

A clevis pack was used to record the deployment and opening forces of the individual recovery parachutes. The package was located within the load coupler; a mechanical device was used as a mechanical linkage at the confluence point where the slings from the platform and the cluster risers of the recovery parachutes are joined; 30,000-pound strain-gage-type tensiometers were located on the individual parachute risers.

A platform pack was used to record the forces on each platform suspension sling. A 60,000-pound strain-gage-type tensiometer was used on each platform sling. In addition to recording these forces, this package was used to record the deceleration force of the platform upon ground impact and to record the extraction force on the last two tests.

Photo Tensiometers:

A 30,000-pound photo tensiometer was also used in each recovery parachute cluster riser.

A 50,000-pound photo tensiometer was used to record the extraction force.

Drop Line:

A 300-foot drop line with a 10-second time-delay was attached to the load on all tests to determine the rate of descent of the load just prior to ground impact.

Stopwatches:

Drop line and extraction times were measured by hand-operated stopwatches.

Cinetheodolite:

Cinetheodolite coverage was used as an alternate source to determine the rate of change of pitch of the aircraft and pitch angle.

Photographic Coverage:

Two 16mm cameras were used in the test aircraft; one was mounted in the flight compartment to photograph the pilot's instrument panel during the tests and one was hand-held in the cargo compartment to photograph the extraction of the load.

One 16mm movie camera was located in a chase plane to photograph the extraction of the load.

One 16mm movie camera and one 70mm sequence still camera were located on the ground to photograph each test.

On the last two tests, a hovering helicopter was used to photograph the extraction and parachute deployment; one 70mm sequence still camera and one 16mm movie camera were used.

TEST PROCEDURES

The aerial unloading kit was installed in the C-130B aircraft and checked for proper fit and ease of installation. Further checks were made to establish the degree of difficulty in loading and securing the "Comex" platforms in the rail system. Upon completion of these ground checks, eight aerial drop tests were conducted to determine operational and reliability characteristics of the aerial unloading kit and the "Comex" platforms.

All drop tests were made from the modified C-130B aircraft flying at an indicated airspeed of 130 or 150 knots and at an altitude of 5000 feet above the drop area. A half-flap setting was used for all drop tests and the throttle setting remained constant throughout each drop after the level flight setting was attained upon approaching the drop zone. On each test the pilot attempted to prevent pitch-up of the aircraft during the extraction of the load by applying forward pressure on the elevator control as soon as he could detect a cg shift.

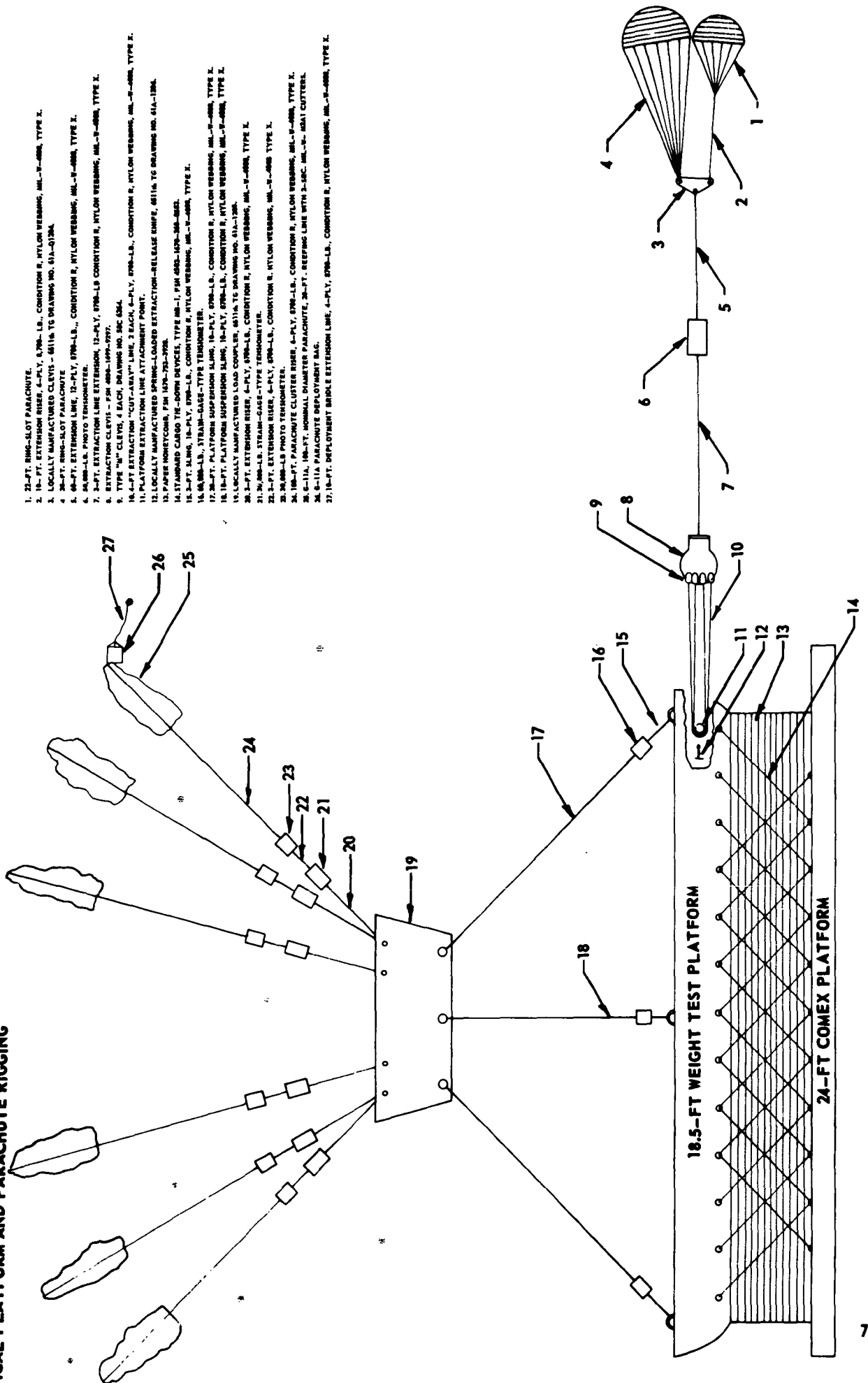
During each test the pilot carefully evaluated the flying qualities (stability and control) of the aircraft.

The gross weight of the loads ranged from approximately 28,300 pounds to 35,010 pounds. An 18.5-foot weight-test platform was used on all drops as the test load since actual vehicles or other drop items were not available. Twelve layers of paper honeycomb were used between the weight-test platform and the 24-foot "Comex" platform on each test to minimize damage to the load on ground impact and to attain an AR/AAV vehicle cg location. The height of cg of the load was approximately 45 inches above the top surface of the "Comex" platform and at approximately the center of the weight-test platform on all tests. Standard rigging techniques and components were used as much as possible. Figure 3 shows the rigging and components used on the first two tests (2364F-60).

FIGURE 3
TYPICAL PLATFORM AND PARACHUTE RIGGING

LEGEND

1. 22-FT. RING-SLOT PARACHUTE.
2. 18-FT. EXTENSION RISER, 4-PLY, 8700-LB., CONDITION R, NYLON WEBSING, MIL-B-4000, TYPE X.
3. LOCALLY MANUFACTURED CLEVIS - 60116 TO DRAWING NO. 61A-0120A.
4. 24-FT. RING-SLOT PARACHUTE.
5. 64-FT. EXTENSION LINE, 12-PLY, 8700-LB., CONDITION R, NYLON WEBSING, MIL-B-4000, TYPE X.
6. 24-FT. PHOTO TENSOMETER.
7. 2-FT. EXTENSION LINE EXTENSION, 12-PLY, 8700-LB., CONDITION R, NYLON WEBSING, MIL-B-4000, TYPE X.
8. EXTENSION CLEVIS - 4 EACH, DRAWING NO. 50C 504.
9. TYPE "MP" CLEVIS, 4 EACH, DRAWING NO. 50C 504.
10. 4-FT. EXTENSION "CUT-AWAY" LINE, 2 EACH, 4-PLY, 8700-LB., CONDITION R, NYLON WEBSING, MIL-B-4000, TYPE X.
11. PLATFORM EXTRACTOR LINE ATTACHMENT POINT.
12. LOCALLY MANUFACTURED SPRING-LOADED EXTRACTION-RELEASE SNIPER, 60116 TO DRAWING NO. 61A-120A.
13. PAPER MONEYCOMP, FM 127-793-3700.
14. STANDARD CARGO TIE-DOWN DEVICES, TYPE MB-1, FM 4502-1470-300-0002.
15. 2-FT. SLING, 18-PLY, 8700-LB., CONDITION R, NYLON WEBSING, MIL-B-4000, TYPE X.
16. 24-FT. PLATFORM SUSPENSION SLING, 18-PLY, 8700-LB., CONDITION R, NYLON WEBSING, MIL-B-4000, TYPE X.
17. 24-FT. PLATFORM SUSPENSION SLING, 18-PLY, 8700-LB., CONDITION R, NYLON WEBSING, MIL-B-4000, TYPE X.
18. LOCALLY MANUFACTURED LOAD COMPLEX, 60116 TO DRAWING NO. 61A-120A.
19. 2-FT. EXTENSION RISER, 4-PLY, 8700-LB., CONDITION R, NYLON WEBSING, MIL-B-4000, TYPE X.
20. 24-FT. STRAIN-GAGE-TYPE TENSOMETER.
21. 24-FT. EXTENSION RISER, 4-PLY, 8700-LB., CONDITION R, NYLON WEBSING, MIL-B-4000, TYPE X.
22. 24-FT. PHOTO TENSOMETER.
23. 18-FT. PARACHUTE CLUSTER RISER, 4-PLY, 8700-LB., CONDITION R, NYLON WEBSING, MIL-B-4000, TYPE X.
24. 6-11A. 18-FT. NORMAL DIAMETER PARACHUTE, 24-FT. REEPLING LINE WITH 2-SEC. MIL-B-2. 6011A CUTTER.
25. 6-11A PARACHUTE DEPLOYMENT BAG.
26. 18-FT. DEPLOYMENT MIDDLE EXTENSION LINE, 4-PLY, 8700-LB., CONDITION R, NYLON WEBSING, MIL-B-4000, TYPE X.
27. 18-FT. DEPLOYMENT MIDDLE EXTENSION LINE, 4-PLY, 8700-LB., CONDITION R, NYLON WEBSING, MIL-B-4000, TYPE X.



Deviations made on later tests are as follows:

1. On tests 2410F-60, 2411F-60, 2441F-60, 0010F-61 and 0011F-61 seven G-11A parachutes with 120-foot cluster risers were used, and the reefing line length of the G-11A parachutes was increased to 40-foot from the standard 20-foot length. Also on these tests a folded 50-foot length bridle with 25 break-ties consisting of one turn of 550-pound tensile strength nylon suspension line spaced at 2-foot intervals was attached to the standard web collar on the apex area of the G-11A parachutes. The other end of the bridle was permanently attached to the deployment bag system. The longer reefing line length was used for the purpose of decelerating the load sufficiently before the overloaded G-11A parachutes were allowed to open fully. Experience gained from previous test programs indicated the change would aid in reducing the damage sustained by the over-

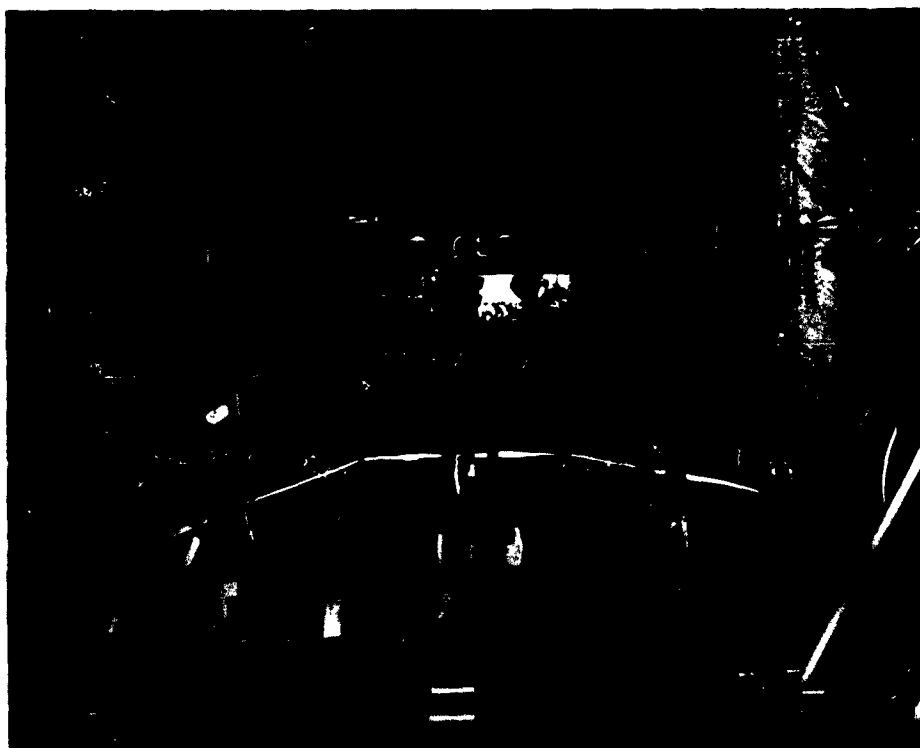
loaded parachutes and thus increase the probability of a successful recovery of the load. The break-tie bridles were also used to minimize damage to the G-11A parachute by providing a more uniform opening.

2. On test 2433F-60 six G-11A parachutes with 40-foot reefing and 2-second cutters were used to recover the load. The break-tie bridles were also used on this test.

3. On tests 0010F-61 and 0011F-61 a 50,000-pound strain-gage-type tensiometer was used in place of the photo-tensiometer to record the extraction force.

The AR/AAV mock-up was used on tests 2410F-60, 2411F-60 and 2433F-60. Figure 2 (page 4) shows the mock-up secured to the load prior to loading and Figure 4 shows the load with the mock-up secured within the aircraft. Close observations were made during loading and extracting to detect any indications of aircraft/load interference.

FIGURE 4



The design of the Aerial Unloading Kit is such that the automatic release of the platform from the rail latch assemblies occurs when the extraction line exerts a pull of approximately 250 pounds. Forces greater than this are often generated prior to complete deployment of the extraction parachute. This would allow the platform to begin rolling aft in the aircraft prior to the opening of the extraction parachute. To prevent this occurrence two break-ties of one turn each of 3000-pound nylon tape were run from the forward end of the platform to tie-down rings on the floor of the aircraft cargo compartment. These were stretched and broken when the extraction force exceeded their breaking strength.

3 TEST RESULTS AND DISCUSSION

The results of the ground checks performed prior to aerial drop tests are as follows: The modified aerial unloading kit, except for minor discrepancies, fits properly in the C-130B aircraft and can easily be handled and installed by two men without special tools. No difficulty was encountered in the rigging or loading of the "Comex" platform and the feature of the aerial unloading kit that provides for automatic "locking in place" of the platform during loading was operationally efficient. The following deficiencies were noted during installation of the aerial unloading kit in the C-130B aircraft:

1. The bottom hinges and hinge attachments on the landing gear inspection plexiglass doors at station 520 and 580 left and right side of the fuselage prohibit installation and lockdown of four sections of conveyor; Section 3LH, Section 4 RH, Section 5LH and Section 6 RH.

2. Litter stanchions will not seat due to the proximity of the rollers at station 535 (Ring D-15) and station 350 (Ring D-6).

3. Phillips-head screws, which are used to attach the rail extensions to the conveyor frame assemblies, become damaged and are hard to remove after several installations.

4. Floor plates around tie-down recesses cause the center conveyor to wobble.

5. The extraction line tie-down tab at ring 30D is covered by the center conveyor.

6. The location and position of the cocking handle of the extraction parachute cable release mechanism is such that it can be damaged and can cause tripping of personnel.

7. Several of the small chains which attach the tie-down washers to the conveyor cross members extend across the tops of the conveyor cross members where they can be damaged or torn off.

8. The locking detent pin handles on the latches are located where they can be easily damaged. Some were found to have a tendency to bind and were hard to operate.

9. During operation, the extraction line can be damaged by contact with the exposed sharp edges and bolt or nut heads on the conveyor frame assemblies and on the auxiliary conveyor.

10. Safety belts or other items in the aircraft can become entangled with the latch release cables and cause a premature release of the platform.

The aerial drop tests were conducted without incident except on test 2441F-60. On this test two separate malfunctions occurred. The first malfunction resulted in the failure of one latch assembly to disengage the platform upon deployment of the extraction parachutes. A snap ring which is used to secure the cable pivot to the actuating level of the latch assembly had fallen off during flight and allowed the cable pivot to disengage from the actuating lever. This severed the connection between the release cable and the latch assembly and prevented the normal release of the latch assembly upon deployment of the extraction parachutes. It is estimated that approximately 2 seconds elapsed after full deployment of the extraction parachutes until a crew member released the platform by operating the manual emergency release system. During this period the airspeed dropped from 150 knots IAS to approximately 130 knots. No recording of the extraction force was obtained on this test, but it is estimated that the peak force exceeded 40,000 pounds. This is based on the recorded forces obtained on later tests. Prior to continuing tests,

the shank of each cable pivot was drilled and cotter pins were used in place of the snap rings to secure the cable pivots to the latch actuating levers.

The second malfunction resulted in ground impact of the load prior to full opening of the recovery parachutes. This was caused by the failure of the spring-loaded knife assembly to sever the extraction line from the load at the time the load cleared the aircraft ramp. Since deployment of the recovery parachutes is also dependent upon this function, the deployment of these parachutes was delayed until the knife assembly finally functioned at an altitude that precluded a normal recovery of the load. Upon ground impact the "Comex" platform was destroyed; however, the test load and instrumentation equipment on the load sustained only minor damage.

During testing with loads of 35,000 pounds (gross weight) it was noted that the bottom of the "Comex" platforms were contacting the top surfaces of some of the conveyor cross members during extraction. Due to the flexibility of the "Comex" platform it tends to sag between the conveyor rows to varying degrees depending upon the loads applied and manner of rigging. This condition could cause the platform to become jammed within the aircraft during extraction or impose a severe concentrated force on a single conveyor cross member with resulting damage to the conveyor assembly, aircraft floor, and platform. It was also noted that the manner in which the load tie-down chains are tensioned is an important factor in this problem. Uniform tensioning of the chains on each side of the load is required. It is understood that the contractor is aware of this problem and that the conveyor cross members on the production model of the aerial unloading kit will be tapered sufficiently to prevent any contact between the platform and the conveyor cross members due to the flexing of the platform.

During the tests the validity of the force measurements on the ramp support arms was questioned. The recorded forces did not seem reliable in view of

the forces obtained during a previous test program where similar loads were dropped from a C-130A aircraft. To resolve this question, static loading tests were conducted on the ramp. The results of the static tests showed that the force measurements obtained on the ramp support arms were reliable but that the ramp hydraulic rams were also supporting a portion of the load. No determination could be made during this test program of the forces sustained by the ramp hydraulic rams during aerial drop tests.

If test 2441F-60 is disregarded (platform destroyed due to a malfunction), 69 percent of the platform panels dropped were reusable without repairs. Some panels were used as many as three times. Table I gives a summary of "Comex" platform recovery information. The drop area was level hard adobe covered with a shallow layer of sandy top soil which was wind drifted to an uneven surface condition. Figure 5 shows a part of the drop area and a typical load after drop.

TABLE I - SUMMARY OF PLATFORM RECOVERY INFORMATION

Drop No.	Number of G-11A Recovery Parachutes	Suspended Load Weight lb	Rate of Descent** ft/sec	Platform Impact Deceleration g	Comex Platform Panel Serial																										Numbers and Damage Codes*	Remarks				
					107	137	112	118	111	130	106	119	138	126	116	106	102	123	104	109	108	105	103	186	114	113	151	183	173	148	190		196	198	182	176
2364F-60	6	26,254	27.8	9.9	N	N	N	N	N	N																									Surface wind 5 knots.	
2365F-60	6	28,134	28.1	9.5	R	X	N	X	N	N																									Surface wind 3 knots.	
2410F-60	7	30,864	25.8	12.3								N	X	X	X	R	X																		Platform contacted ground when broadside to direction of drift. Right rail bent. Surface wind 14 knots.	
2411F-60	7	32,409	26.9	10.5														R	X	R	R	R	R											No surface wind.		
2433F-60	6	32,706	34.1	---																					X	R	N	N	R	N				No surface wind.		
2441F-60	7	32,409	---	---	X		X		X	X	X	X																							Platform contacted ground prior to recovery parachute attaining full open condition. Both rails were destroyed.	
0010F-61	7	32,409	28.6	---														X		X	X	X	R	X											Platform contacted ground when broadside to direction of drift. Left rail bent. Surface wind 10 knots.	
0011F-61	7	32,409	25.2	---																										N	N	N	N	R	N	Surface wind 10 knots.

*Code: N - No damage
R - Light damage but reusable without repair
X - Damaged beyond repair
**Corrected to NACA standard atmosphere at sea level

FIGURE 5

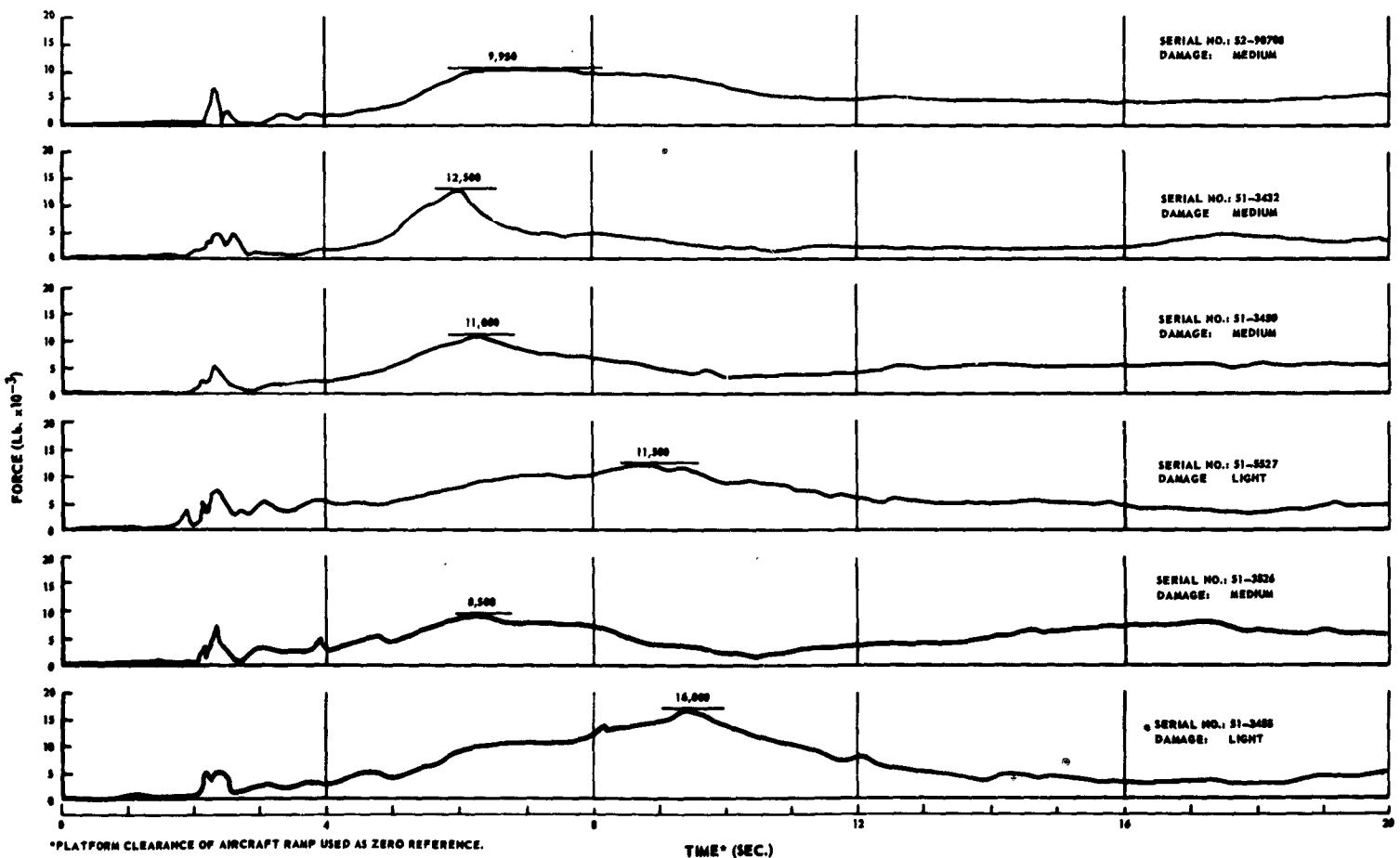


Tables II through XIV give force-time histories of the recovery parachutes and platform suspension slings. On test 2411F no parachute forces were obtained and on test 2441F neither the parachutes nor platform suspension sling forces were obtained. The extent of damage sustained by each parachute is also given in these tables. The following four general evaluative classifications of damage were used:

1. Light Damage - reusable without repair.
2. Medium Damage - economically repairable.
3. Heavy Damage - not economically repairable but remained inflated.
4. Destroyed - not economically repairable and did not remain inflated.

TABLE II

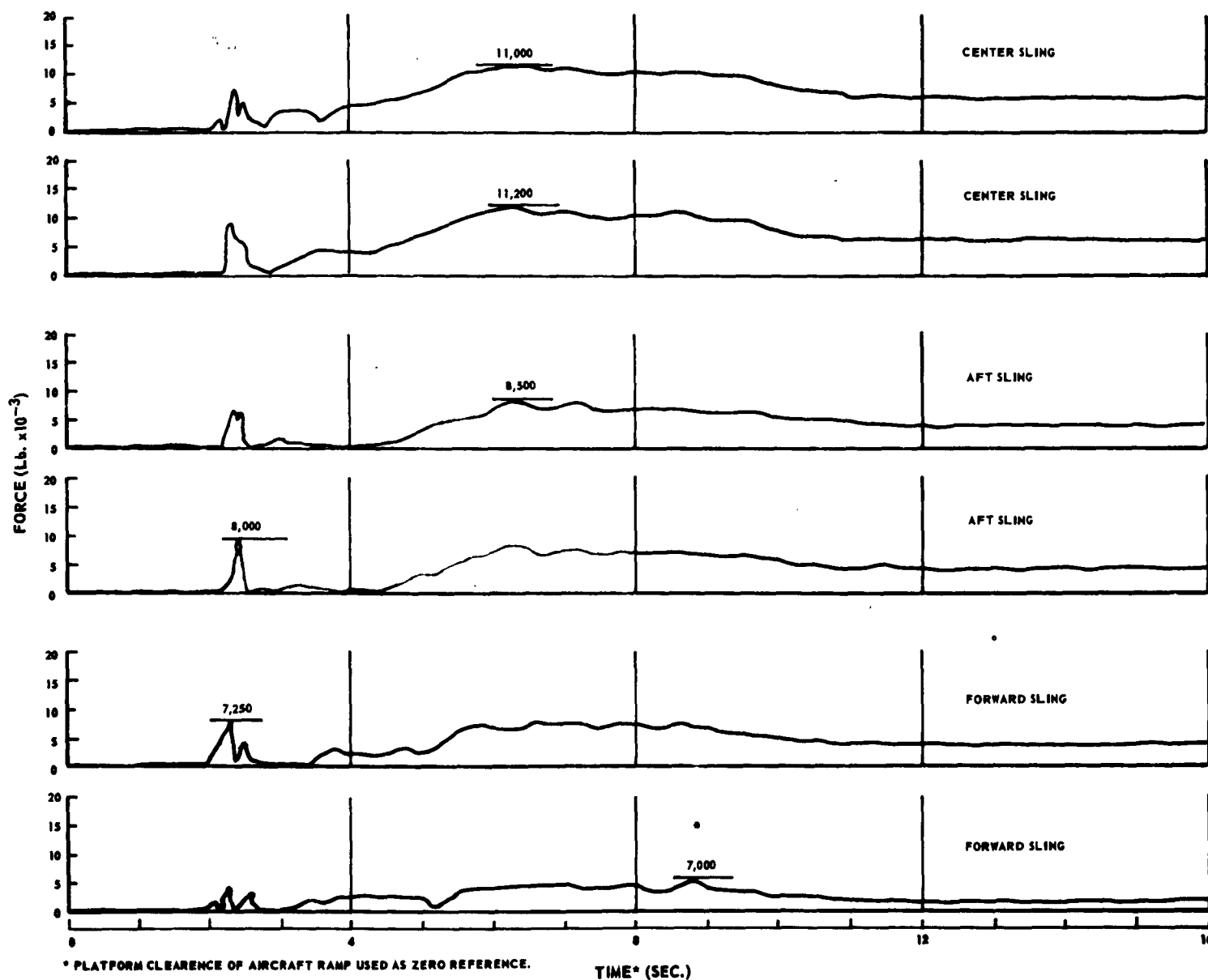
DROP NO.: 2364F-60
 DATE: 14 DECEMBER 1960
 RECOVERY PARACHUTES: 6 G-11A
 G-11A REEFING: 20 FT., 2 SEC.
 EXTRACTION PARACHUTES: CLUSTER OF
 ONE 22-FT. AND ONE 28- FT. RING-SLOT
 LOAD GROSS WEIGHT: 28,300 LBS.
 DROP SPEED: 130 KIAS
 DROP ALTITUDE: 5000 FT.



FORCE VERSUS TIME HISTORIES OF G-11A RECOVERY PARACHUTES

TABLE III

DROP NO. 2344F-60
 DATE: 14 DECEMBER 1960
 RECOVERY PARACHUTES: 6 - G-11A
 G-11A REEFING: 20 FT., 2 SEC.
 EXTRACTION PARACHUTES: CLUSTER OF
 ONE 22-FT. AND ONE 28-FT. RING-SLOT
 LOAD GROSS WEIGHT: 28,300 LBS.
 DROP SPEED: 130 KIAS
 DROP ALTITUDE: 5000 FT.



FORCE VERSUS TIME HISTORIES OF G-11A RECOVERY PARACHUTES

TABLE IV

DROP NO.: 2365F-60
 DATE: 16 DECEMBER 1962
 RECOVERY PARACHUTES: 6 G-11A
 G-11A REEFING: 20 FT., 2 SEC.
 EXTRACTION PARACHUTES: CLUSTER OF
 ONE 22-FT. AND ONE 28-FT. RING SLOT
 LOAD GROSS WEIGHT: 30,180 LBS.
 DROP SPEED: 130 KIAS
 DROP ALTITUDE: 5,000

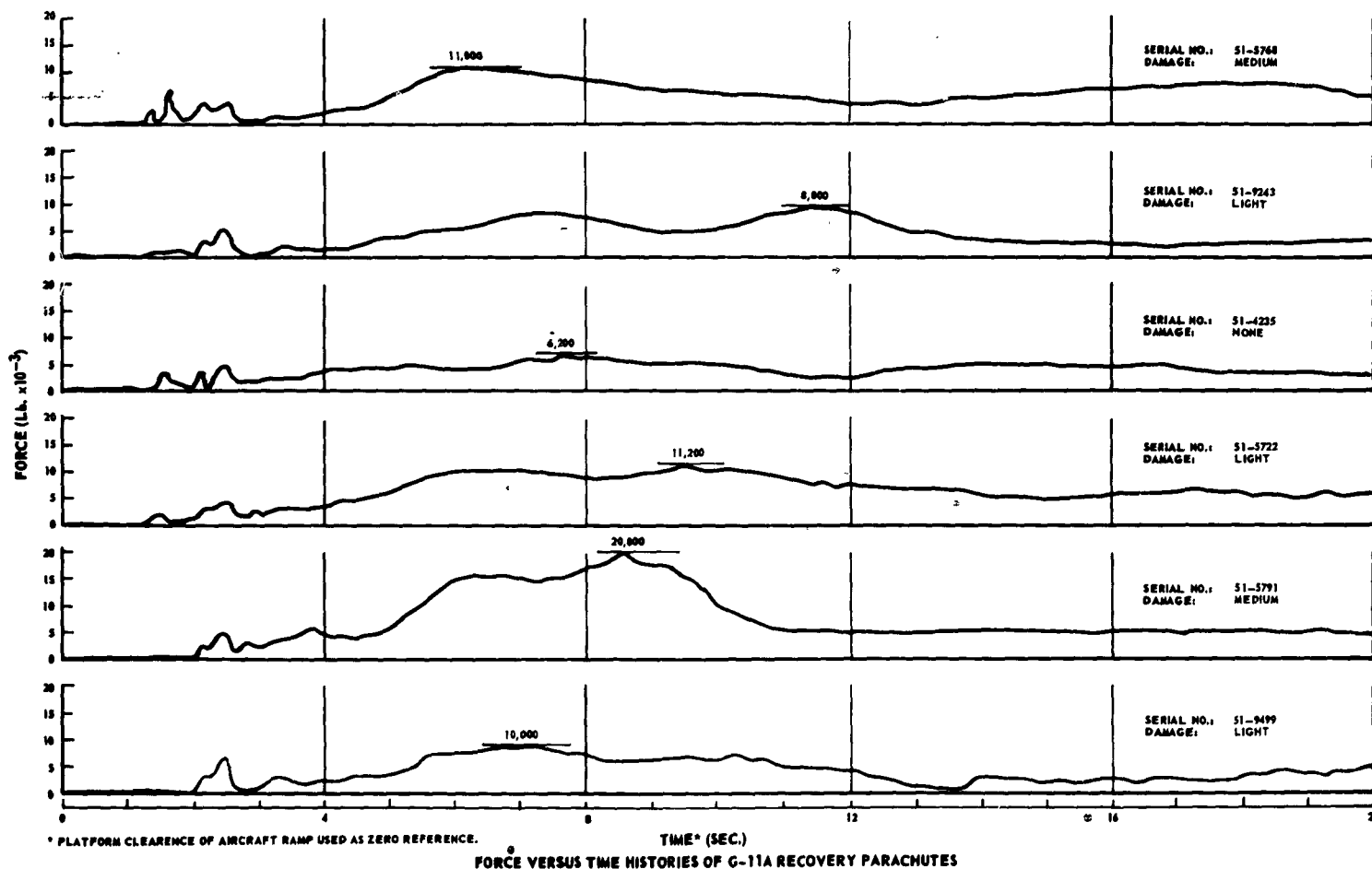
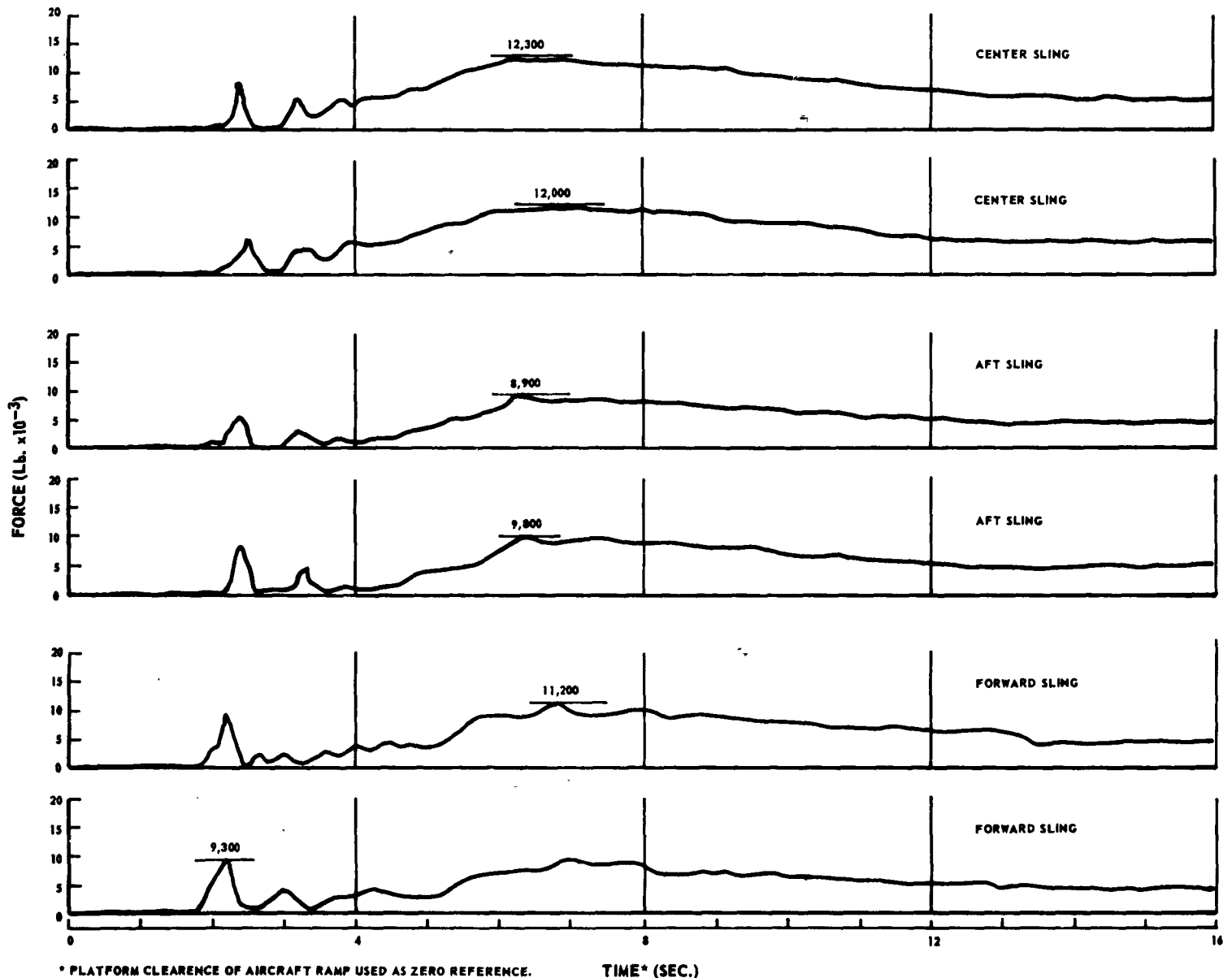


TABLE V

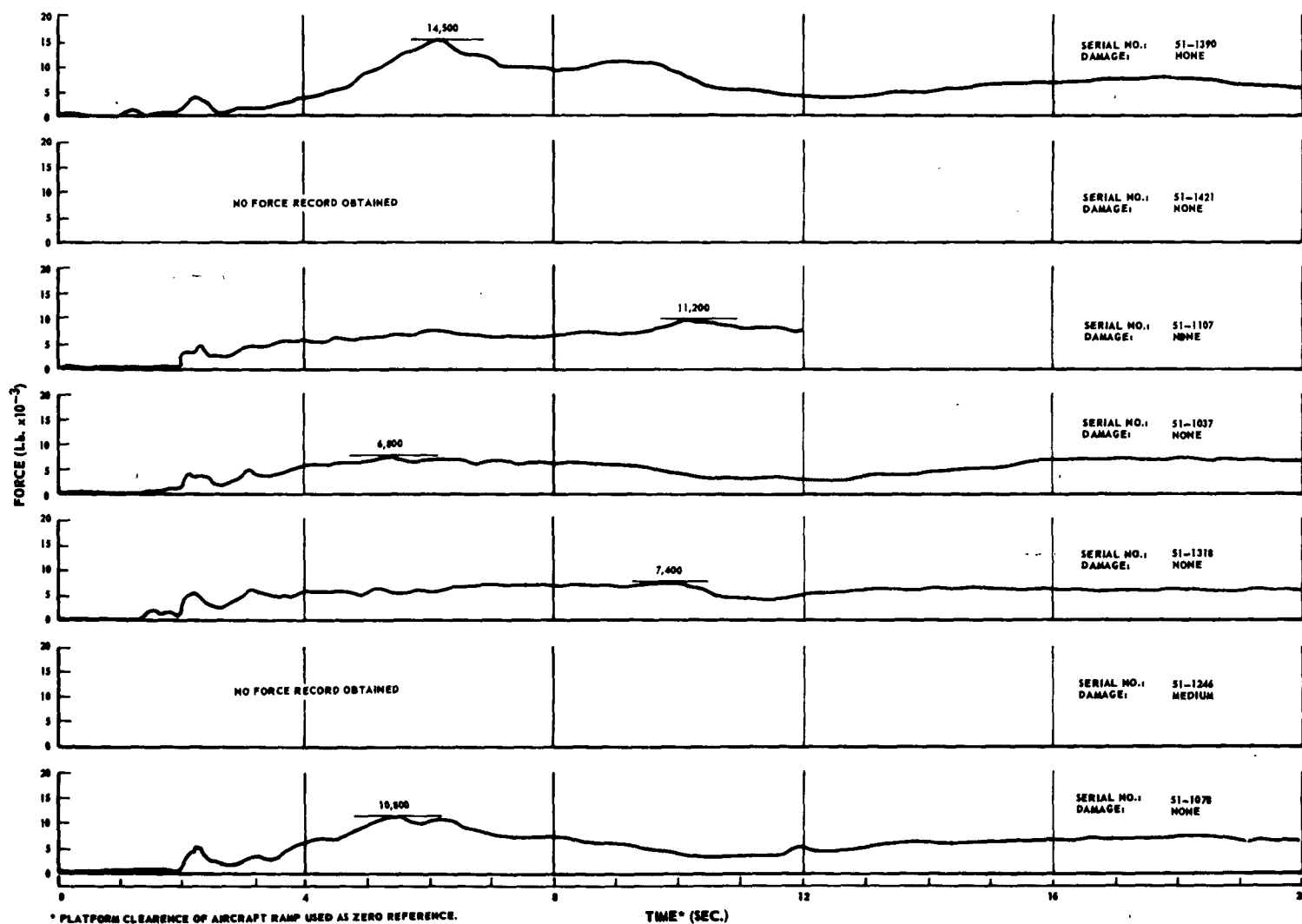
DROP NO.: 2345F-60
 DATE: 16 DECEMBER 1960
 RECOVERY PARACHUTES: 6 G-11A
 G-11A REEFING: 20 FT., 2 SEC.
 EXTRACTION PARACHUTES: CLUSTER OF
 ONE 22-FT. AND ONE 28-FT. RING SLOT
 LOAD GROSS WEIGHT: 30,180 LBS.
 DROP SPEED: 130 KIAS
 DROP ALTITUDE: 5,000 FT.



FORCE VERSUS TIME HISTORIES OF PLATFORM SUSPENSION SLINGS

TABLE VI

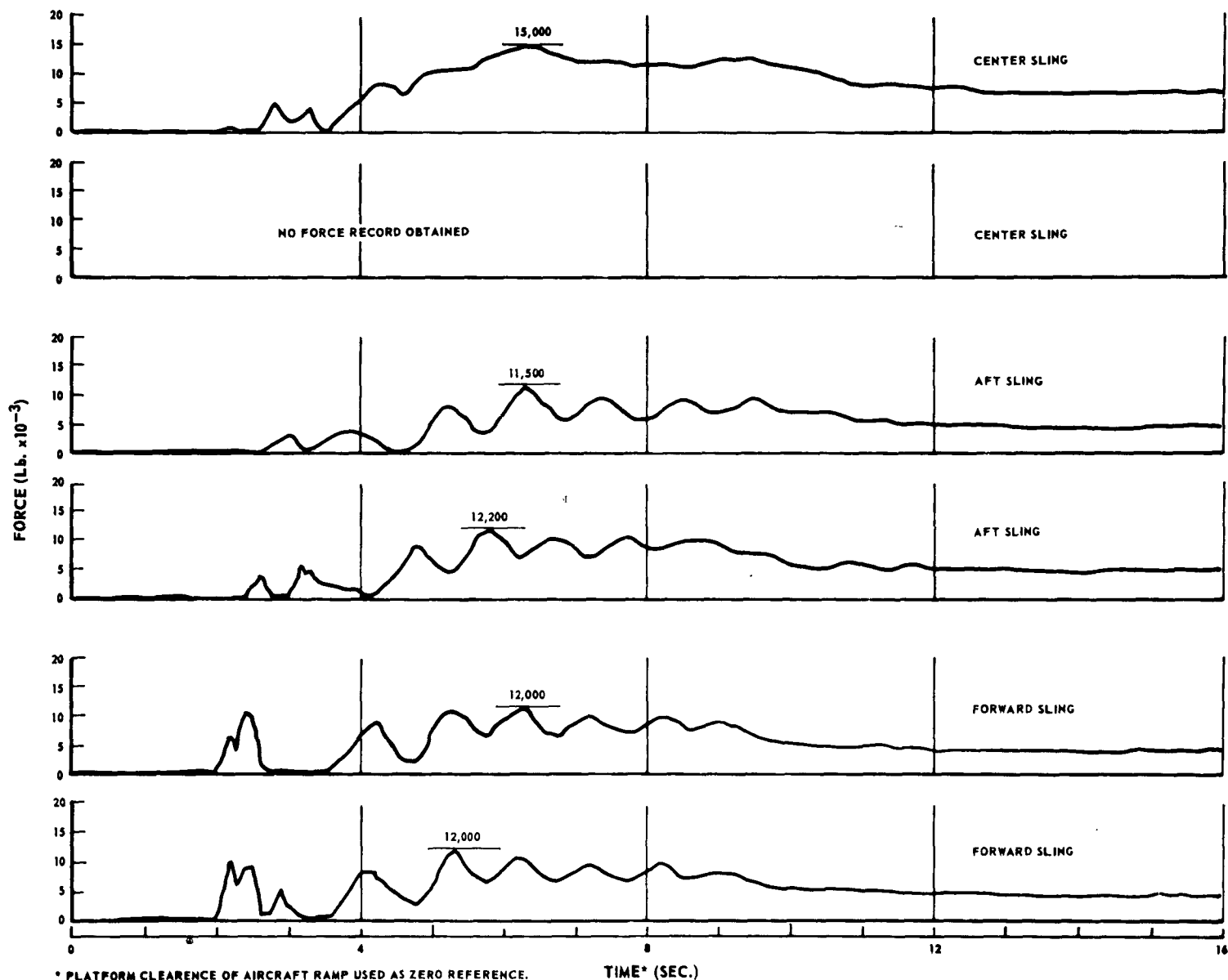
DROP NO.: 2410F-60
 DATE: 20 DECEMBER 1960
 RECOVERY PARACHUTES: 7G-11A
 G-11A REEFING: 40 FT. 2 SEC.
 EXTRACTION PARACHUTES: CLUSTER
 OF TWO 28-FT. RING-SLOTS
 LOAD GROSS WEIGHT: 33,465 LBS.
 DROP SPEED: 130 KIAS
 DROP ALTITUDE: 5,000 FT



FORCE VERSUS TIME HISTORIES OF G-11A RECOVERY PARACHUTES

TABLE VII

DROP NO. 1 2411F-6
 DATE: 23 DECEMBER 1960
 RECOVERY PARACHUTES: 7 G-11A
 G-11A REEFING: 40 FT., 2 SEC.
 EXTRACTION PARACHUTES: CLUSTER
 OF TWO 28-FT. RING-SLOTS.
 LOAD GROSS WEIGHT: 35,010 LBS.
 DROP SPEED: 130 KIAS
 DROP ALTITUDE: 5,000 FT.



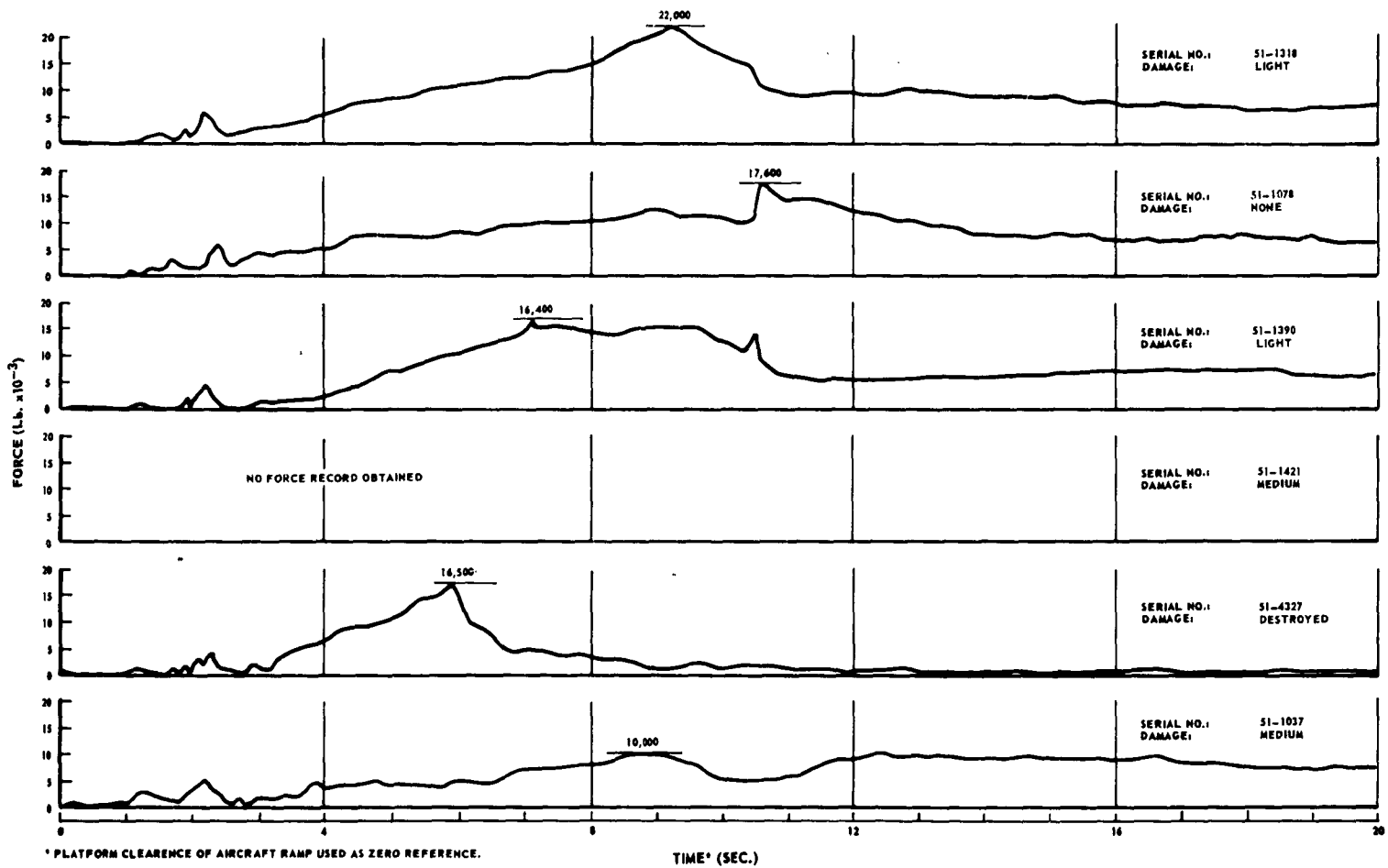
* PLATFORM CLEARENCE OF AIRCRAFT RAMP USED AS ZERO REFERENCE.

TIME* (SEC.)

FORCE VERSUS TIME HISTORIES OF PLATFORM SUSPENSION SLINGS

TABLE VIII

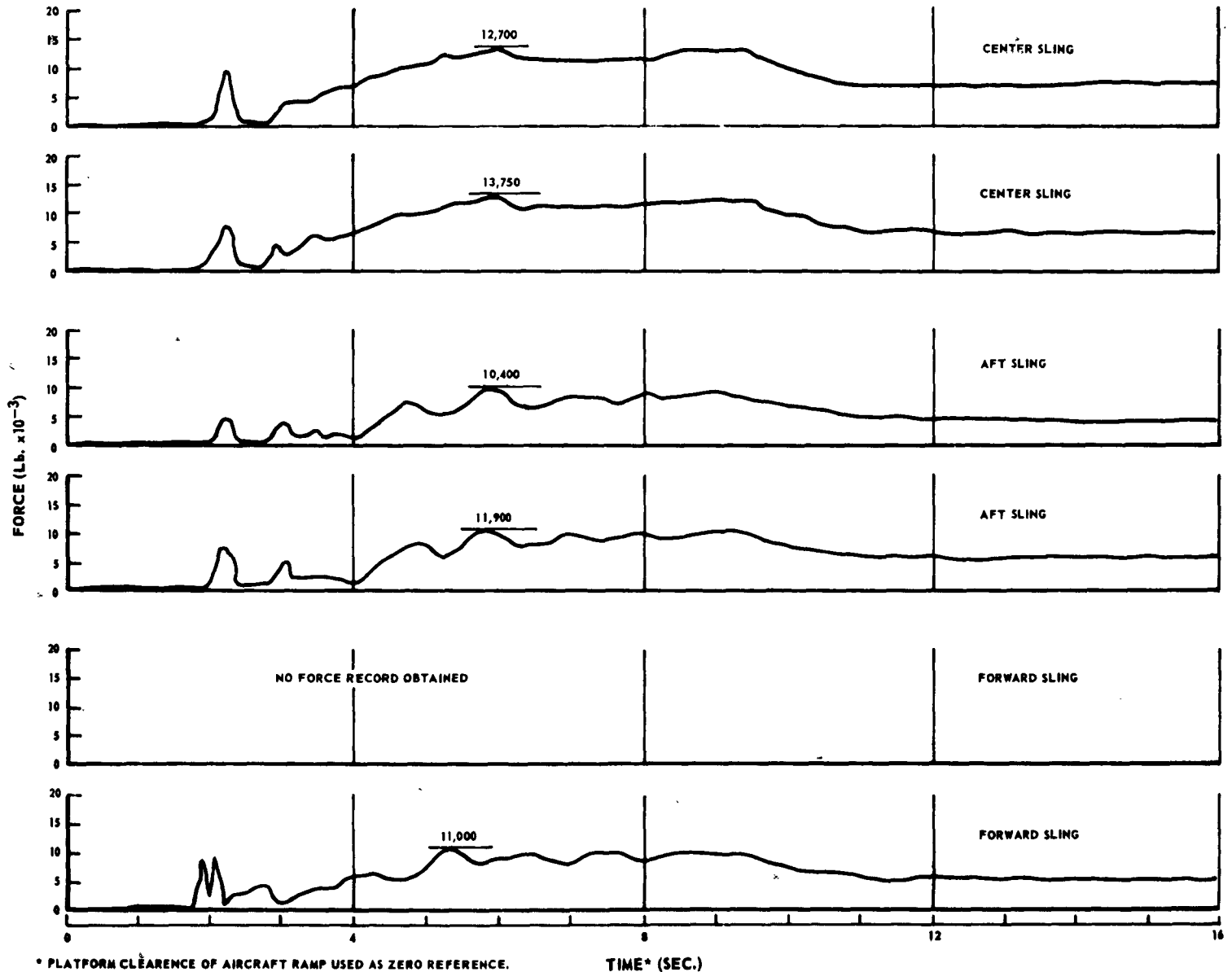
DROP NO.: 2433F-60
 DATE: 30 DECEMBER 1960
 RECOVERY PARACHUTES: 6 G-11A
 G-11A REEFING: 20 FT., 2 SEC.
 EXTRACTION PARACHUTES: CLUSTER OF
 ONE 22-FT. AND ONE 28-FT. RING SLOT
 LOAD GROSS WEIGHT: 35,010 LBS.
 DROP SPEED: 130 KIAS
 DROP ALTITUDE: 5,000 FT



FORCE VERSUS TIME HISTORIES OF G-11A RECOVERY PARACHUTES

TABLE IX

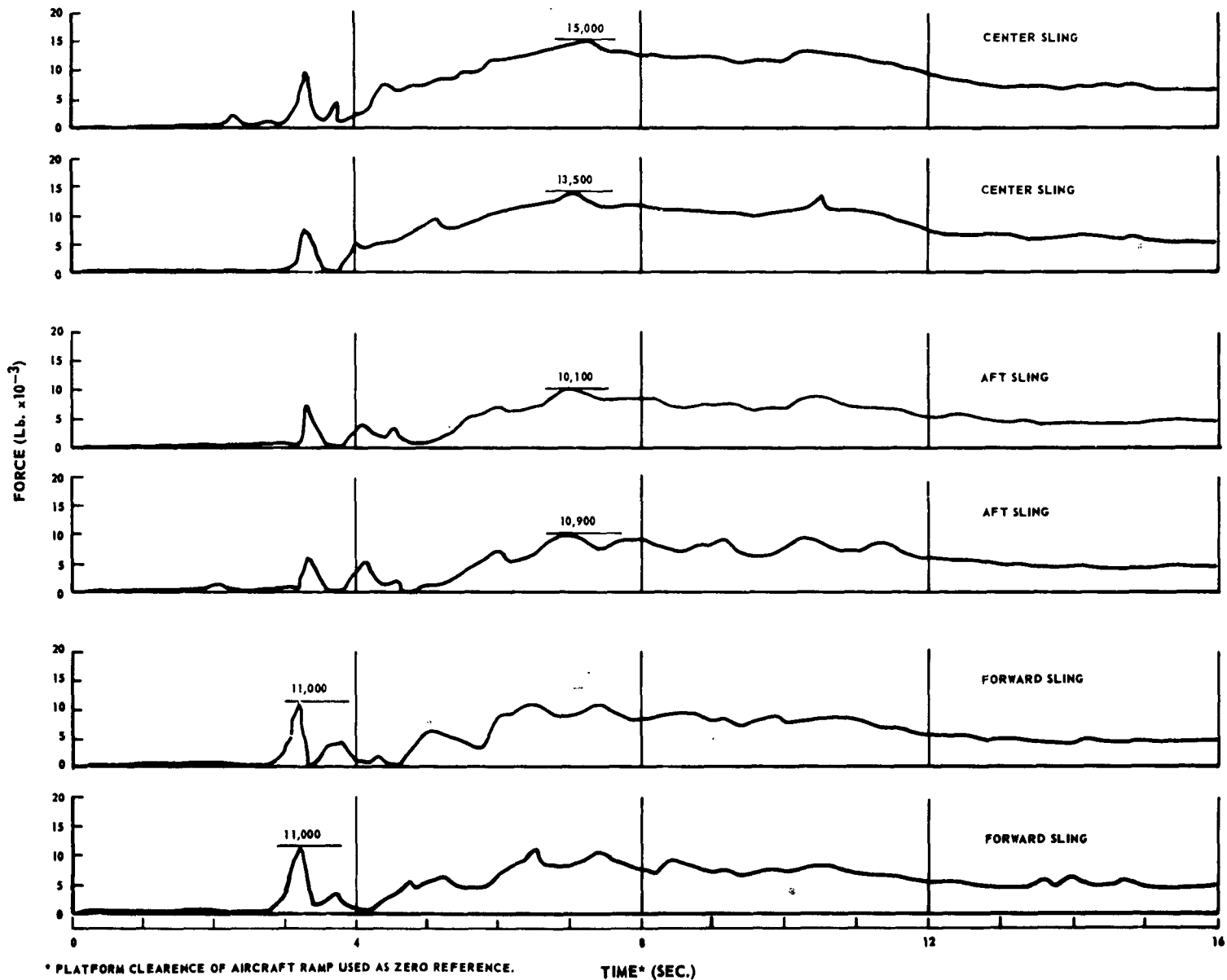
DROP NO.: 2433F-60
 DATE: 30 DECEMBER 1960
 RECOVERY PARACHUTES: 6 G-11A
 G-11A REEFING: 20 FT., 2 SEC.
 EXTRACTION PARACHUTES: CLUSTER OF
 ONE 22-FT. AND ONE 28-FT. RING SLOT
 LOAD GROSS WEIGHT: 35,010 LBS
 DROP SPEED: 130 KIAS
 DROP ALTITUDE: 5,000 FT.



FORCE VERSUS TIME HISTORIES OF PLATFORM SUSPENSION SLINGS

TABLE X

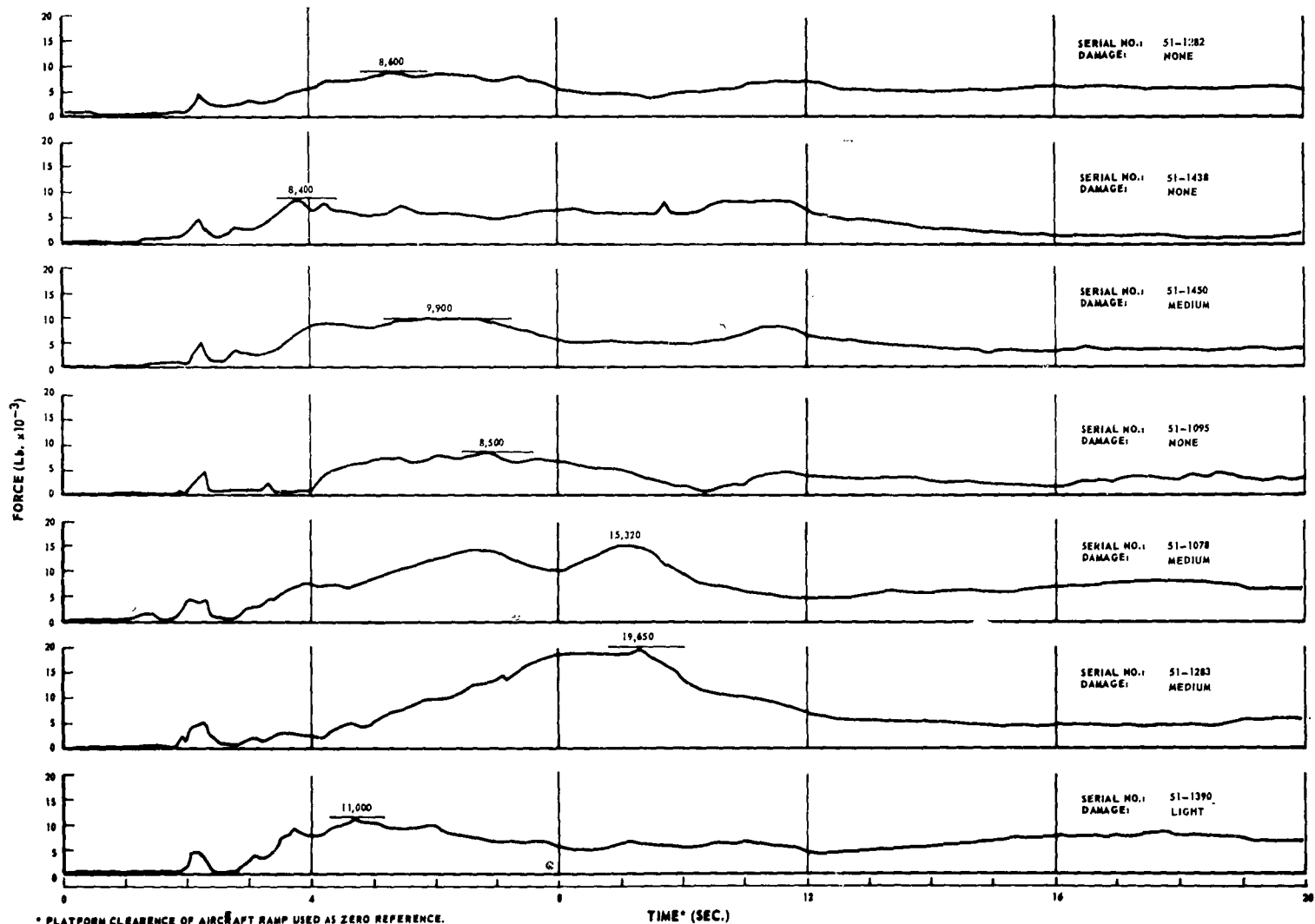
DROP NO.: 2410F-60
 DATE: 20 DECEMBER 1960
 RECOVERY PARACHUTES: 7 G-11A
 G-11A REEFING: 40 FT., 2 SEC.
 EXTRACTION PARACHUTES: CLUSTER
 OF TWO 28-FT. RING-SLOTS
 LOAD GROSS WEIGHT: 33,465 LBS.
 DROP SPEED: 130 KIAS
 DROP ALTITUDE: 5,000 FT.



FORCE VERSUS TIME HISTORIES OF PLATFORM SUSPENSION SLINGS

TABLE XI

DROP NO.: 0010F-61
 DATE: 16 JANUARY 1960
 RECOVERY PARACHUTES: 7 G-11A
 G-11A REEFING: 40 FT., 2SEC.
 EXTRACTION PARACHUTES: CLUSTER
 OF TWO 28-FT. RING-SLOTS
 LOAD GROSS WEIGHT: 35,010 LBS.
 DROP SPEED: 150 KIAS
 DROP ALTITUDE: 5,000 FT.

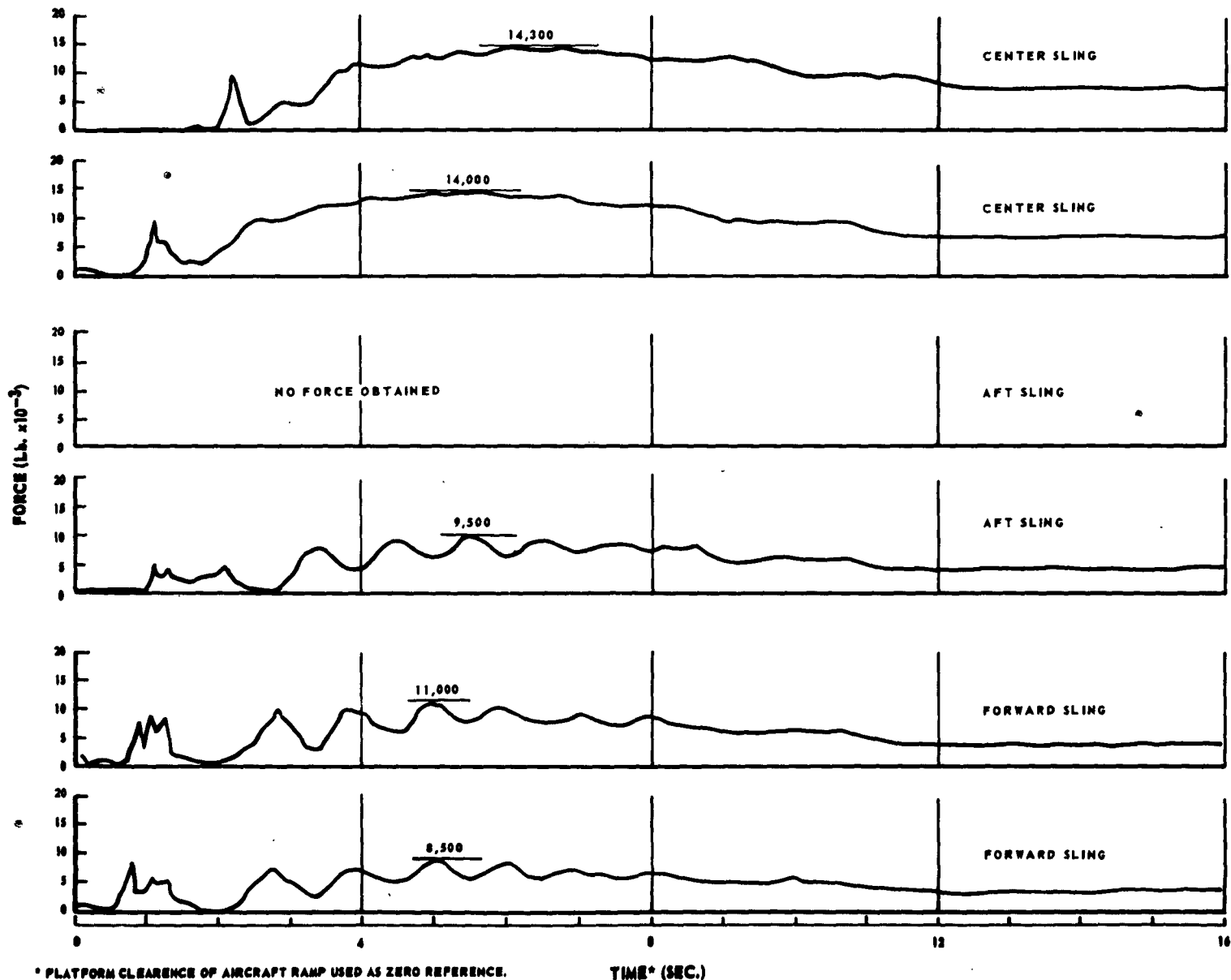


* PLATFORM CLEARANCE OF AIRCRAFT RAMP USED AS ZERO REFERENCE.

FORCE VERSUS TIME HISTORIES OF G-11A RECOVERY PARACHUTES

TABLE XII

DROP NO.: 0010F-61
 DATE: 16 JANUARY 1961
 RECOVERY PARACHUTES: 7 G-11A
 G-11A REEFING: 40 FT., 2 SEC.
 EXTRACTION PARACHUTES: CLUSTER
 OF TWO 28-FT. RING-SLOTS
 LOAD GROSS WEIGHT: 35,010 LBS.
 DROP SPEED: 150 KIAS
 DROP ALTITUDE: 5,000 FT.



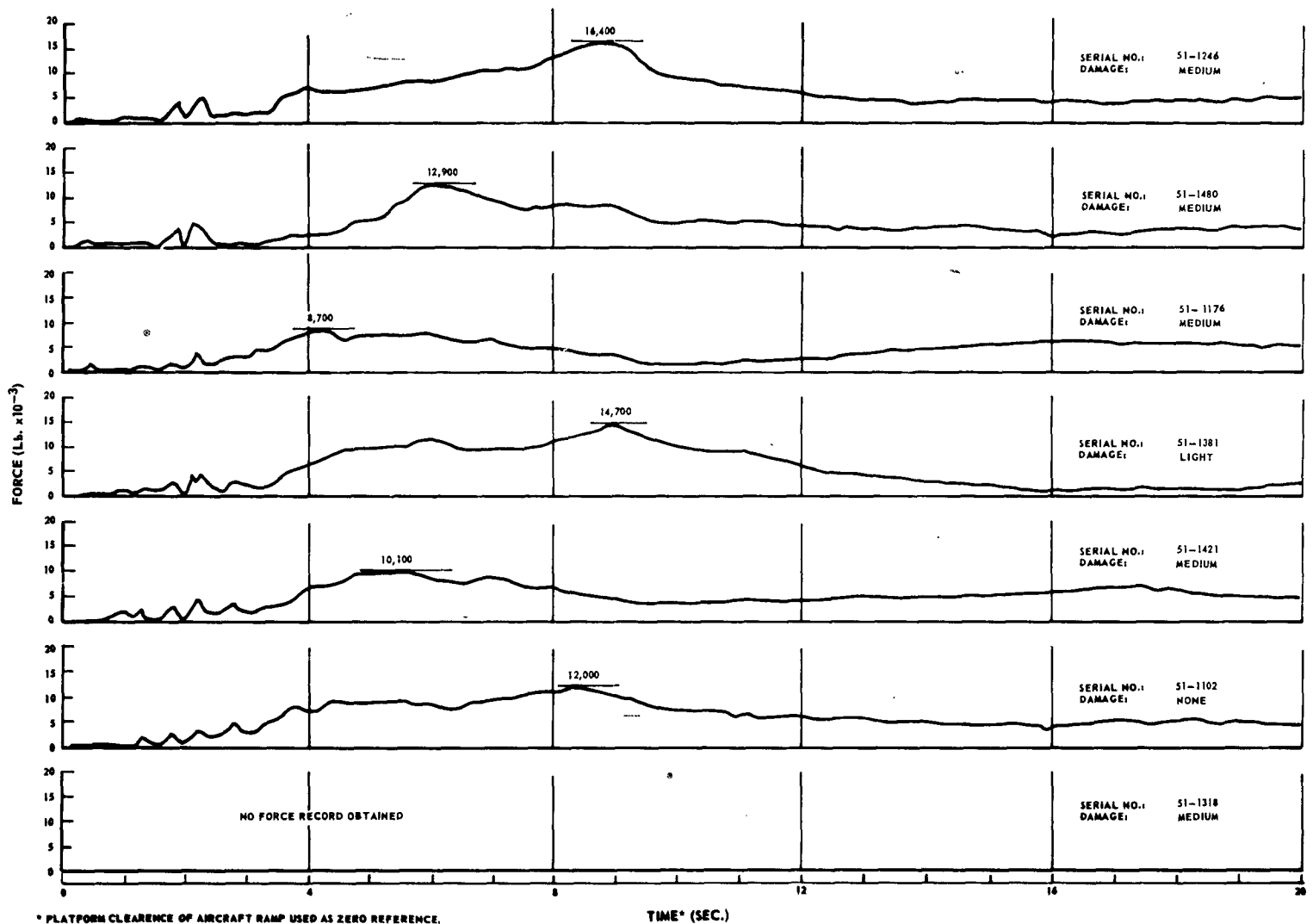
* PLATFORM CLEARANCE OF AIRCRAFT RAMP USED AS ZERO REFERENCE.

TIME* (SEC.)

FORCE VERSUS TIME HISTORIES OF PLATFORM SUSPENSION SLINGS

TABLE XIII

DROP NO.: 0011F-61
 DATE: 19 JANUARY 1961
 RECOVERY PARACHUTES: 7 G-11A
 G-11A REEFING: 40 FT., 2 SEC.
 EXTRACTION PARACHUTES: CLUSTER
 OF TWO 28-FT. RING-SLOTS.
 LOAD GROSS WEIGHT: 35,010 LBS.
 DROP SPEED: 150 KIAS
 DROP ALTITUDE: 5,000 FT.



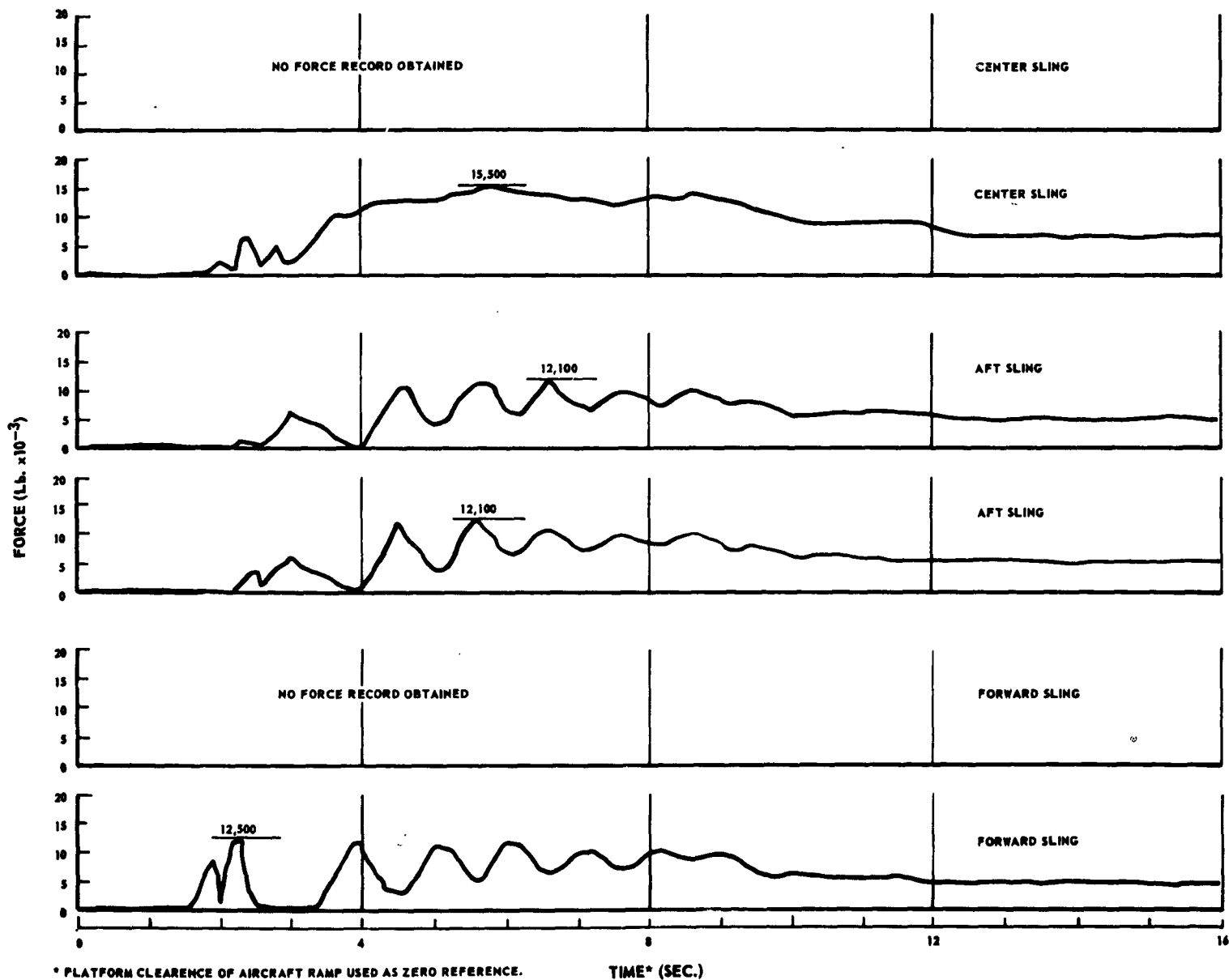
* PLATFORM CLEARANCE OF AIRCRAFT RAMP USED AS ZERO REFERENCE.

TIME* (SEC.)

FORCE VERSUS TIME HISTORIES OF G-11A RECOVERY PARACHUTES

TABLE XIV

DROP NO.: 0011F-61
 DATE: 19 JANUARY 1961
 RECOVERY PARACHUTES: 7 G-11A
 G-11A REEFING: 40 FT., 2 SEC.
 EXTRACTION PARACHUTES: CLUSTER
 OF TWO 28 -FT. RING SLOTS.
 LOAD GROSS WEIGHT: 35,010 LBS.
 DROP SPEED: 150 KIAS
 DROP ALTITUDE: 5,000 FT.



FORCE VERSUS TIME HISTORIES OF PLATFORM SUSPENSION SLINGS

The AR/AAV wooden mock-up did not present any problem. No aircraft load interference was noted at any time.

Five different pilots flew the aircraft during the test program and all agreed that there was no evidence of stability or control problems. On all tests the aircraft was in a stable flight attitude with no noticeable yaw or bank at the time the extraction cycle was initiated. The gross weight of the loaded aircraft ranged from 122,944 pounds to 132,944 pounds. No turbulence was encountered during any of the drop tests. The calculated ratio of extraction force to load gross weight ranged between .8 to 1.2 for the tests conducted. The extraction times ranged from 3.1 to 4.2 seconds with exception of test 2441F-60 where the malfunction delayed the normal extraction cycle. On the first five tests which included two 35,000-pound drops, the airspeed was 130 knots indicated and was maintained within plus or minus 2 knots throughout the drop cycle. On the last three tests which were all 35,000-pound drops, the airspeed was 150 knots indicated and

was maintained within plus or minus 6 knots except on test 2441F-60 where the airspeed fell off 20 knots in 2 seconds due to the malfunction. On all tests the drop altitude was maintained to within plus or minus 60 feet during platform extraction.

From visual observations of the tests, it was determined that the application of forward elevator control by the pilot did not entirely prevent pitch-up of the aircraft during extraction of the load on the tests. Since cinetheodolite data was not obtained during some of the tests and because of failure of the pitch and rate of pitch gyros on some tests, an accurate determination of the pitch attitude of the aircraft just prior to, during, and immediately following the drop could not be made for all tests. However, sufficient data was obtained during tests 2441F-60, 0010F-61, and 0011F-61 to determine accurately the pitch attitude of the aircraft on these tests.

Table XV gives a summary of test information and results.

TABLE XV - SUMMARY OF TEST INFORMATION AND RESULTS
All tests were made from C-130B Aircraft (S/N 59-1536) at an altitude of 5000 feet above the test area.

Drop No.	Airspeed IAS-kt	Gross Weight Aircraft lb	Gross Weight Load lb	Extraction Parachutes No. and Type	Extraction Force lb	Extraction Time sec	Velocity of Platform as it Leaves Aircraft-ft/sec	Ramp Support Arm Forces lb	Initial Aircraft Pitch Attitude Prior to Drop - deg	Maximum Aircraft Pitch Attitude During Drop - deg	Minimum Aircraft Pitch Attitude During Aircraft Recovery After Drop - deg	Maximum Change in Aircraft Pitch Attitude - deg	Aircraft Accelerations					Tail (Vertical)
													Nose (Vertical)	Center of Gravity of Aircraft Vertical	Longitudinal	Lateral		
2364F-60	130	131,294	28,300	Cluster of 1 ea. 28-ft ring slot and 1 ea. 22-ft ring slot	*	4.1	50.0	Left 13,100 Right 13,900	***	***	***	***	0.57 ±0.05	0.68 ±0.05	0	0		1.45 ±0.05
2365F-60	130	125,074	30,180	Cluster of 1 ea. 28-ft ring slot and 1 ea. 22-ft ring slot	*	3.1	43.5	Left 12,200 Right 14,000	***	***	***	***	0.7 ±0.05	0.89 ±0.05	0	0		1.40 ±0.15
2410F-60	130	128,959	33,465	Cluster of 2 ea. 28-ft ring slots	*	4.0	43.5	Left 9,750 Right 11,650	***	***	***	***	0.52 ±0.05	0.90 ±0.08	0	0		2.27 ±0.15
2411F-60	130	127,744	35,010	Cluster of 2 ea. 28-ft ring slots	*	3.6	45.4	Left 12,900 Right 15,100	***	***	***	***	0.50 ±0.05	0.78 ±0.05	0	0		---
2433F-60	130	130,629	35,010	Cluster of 2 ea. 28-ft ring slots	*	4.2	50.0	Left 20,800 Right 21,200	***	***	***	***	0.72 ±0.05	0.98 ±0.05	0	0	0.075 ±0.01	1.95 ±0.20
2441F-60	.50	132,944	35,010	Cluster of 2 ea. 28-ft ring slots	*	6.2	52.6	Left 18,400 Right 21,300	2.00	9.25	-1.75	11.00	0.85 ±0.05	1.35 ±0.10	0	0	0.05 ±0.01	2.40 ±0.20
0010F-61	150	124,944	35,010	Cluster of 2 ea. 28-ft ring slots	30,700**	4.0	50.0	Left 15,100 Right 18,200	1.75	4.75	0.50	4.25	0.80 ±0.05	1.25 ±0.08	0	0	0.19 ±0.05	2.40 ±0.15
0011F-61	150	127,744	35,010	Cluster of 2 ea. 28-ft ring slots	39,500	3.9	50.0	Left 12,200 Right 13,500	2.00	7.25	1.25	6.00	0.70 ±0.05	1.10 ±0.10	0	0	0.20 ±0.05	1.70 ±0.15

*Tensiometer failure.

**One extraction parachute did not obtain full opening.

***Insufficient data obtained to provide accurate determination.

4 CONCLUSIONS

The following conclusions are drawn from the tests under the conditions tested:

1. The Aerial Unloading Kit, Model AF/A32H-1, although generally functionally suitable for usage with the 108-inch "Comex" platform for drops in the range of 27,500 to 35,000 pounds, should not be accepted for operational use until modifications are accomplished to:

- a. Prevent the platform from contacting the conveyor cross members during loading and extraction.
- b. Provide protection covers for the release cables.
- c. Provide positive locking attachments to secure the release cable pivots to the latch actuating levers.
- d. Protect the cocking handle

of the extraction parachute cable release mechanism from damage.

2. The 24-foot "Comex" platform is suitable for air drops of unit loads of from 27,500 to 35,000 pounds.

3. Although no stability or control problems were encountered and no evidence of structural damage to the aircraft became apparent during these tests, adequate instrumentation of the aircraft was not available for the tests to determine if any flight safety conditions may exist from exceeding the design limitations of the aircraft when air dropping unit loads with weights ranging from 27,500 to 35,000 pounds.

4. The results of the tests indicate that the AR/AAV vehicle could be air dropped from a C-130B aircraft without encountering any aircraft load-clearance problems.

Air Force Flight Test Center, Edwards AF Base, Calif. Report No. FTC-TDR-62-17, C-130 Dual Rail Aerial Delivery System for Heavy Equipment Drop. Final report, Feb. 62, 10 p incl illust., tables.

Unclassified Report

This report presents the results of a program to evaluate a C-130 dual rail modification for a fixed pin 108-inch platform usage for single unit drops in the range of 27,500 to 35,000 pounds, an evaluation of the fixed pin 108-inch "Comex" combat expendable platform, and evaluation of flying qualities (stability and control) of the C-130B during heavy drop aerial delivery. Force-time histories during parachute deployment and opening in the individual load suspension slings and parachute risers were obtained.

1. C-130 Aerial Delivery System
2. Dual Rail Aerial Delivery System
3. System for Heavy Equipment Parachute Drop
 - I. Project No. 8044
 - II. Thomas A. Olson, Captain USAF
 - III. In ASTIA Collection

Air Force Flight Test Center, Edwards AF Base, Calif. Report No. FTC-TDR-62-17, C-130 Dual Rail Aerial Delivery System for Heavy Equipment Drop. Final report, Feb. 62, 10 p incl illust., tables.

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Tests determined that the Aerial Unloading Kit, Model AF/A32H-1, although generally functionally suitable for use with the 108-inch "Comex" platform for drops in the range of 27,500 to 35,000 pounds, should not be accepted for operational use until the modifications as recommended in this report are accomplished. The 24-foot "Comex" platform is suitable for air drops of unit loads of from 27,500 to 35,000 pounds. Inadequate instrumentation prevented the determination of any flight conditions involving the exceeding of design limitations of the aircraft when air dropping unit loads with weights ranging from 27,500 to 35,000 pounds. Test results also indicate that the AR/AAV vehicle can be dropped from a C-130B aircraft without encountering any aircraft load-clearance problems.

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